ANALYSIS OF TAILINGS POND SEEPAGE FLOW TO RED RIVER

AT

UNOCAL 76 MOLYCORP, INC.

QUESTA DIVISION

VAIL ENGINEERING, INC.

SANTA FE, NEW MEXICO

SEPTEMBER 24, 1993

VAIL ENGINEERING, INC.

PHONE: (505) 988-3575

1588 SAN MATEO LANE
SANTA FE, NEW MEXICO
87501

September 24, 1993

Mr. David Shoemaker
Mine Manager
Molycorp, Inc.
P.O. Box 469
Questa, NM 87556

Dear Sir:

Submitted herewith is our report on the stream survey and analysis of accretions to Red River in the vicinity of Molycorp's tailings ponds, Taos County, New Mexico.

Sincerely yours,
VAIL ENGINEERING, INC.

Ralph E. Vail

Chief Engineer
NMPE No. 2098

REGISTERED PROFESSIONAL ENGINEER
STATE OF NEW MEXICO
No. 2098
RALPH EVERETT VAIL

160002

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ANALYSIS OF TAILINGS POND SEEPAGE FLOW TO RED RIVER

OVERVIEW

Molycorp's tailings dams are located primarily in Sections 35 (Dam Nos. 4 & 5) and 36 (Dam No. 1), of Township 29N Range 12E NMPM, one to two miles west of the Town of Questa, Taos County, New Mexico. Red River flows to the west past the tailings ponds at a distance of approximately one-half mile south of the ponds. Leachate from the tailings ponds seeps to the ground water which flows generally in a southwesterly direction and discharges to Red River.

The seepage from the ponds contains elevated concentrations of sulfates (840± mg/l), molybdenum (2± mg/l), manganese (1.4± mg/l), and total dissolved solids (1700± mg/l). Several other elements are present at moderately elevated but below significant levels. It appears that most of the molybdenum is being absorbed during seepage flow in the vadose zone and along the ground water flow path.

During the 1970's Molycorp excavated trenches and installed french drains to intercept the seepage flow south of Dam No. 1 and southeast of Dam No. 4. These seepage barriers appeared to be fairly effective for some time but recently there has been evidence that an increased amount of seepage from the tailings ponds flows past these barriers. This seepage flow is generally in the shallow alluvium and the fairly high constituent concentrations this area.

It is probable that a large percentage of the seepage from section 35 is transported by the ground water flow in the volcanic formations which underlie most of this pond area. It is believed that most of this ground water flow is discharged to Red River at the numerous springs along the Red River Gorge. The accretion to Red River from spring flow between the head of the gorge to the State fish hatchery is on the order of 18 cfs indicating a large amount of ground water flow in the volcanic formation.

In April 1993 a water quality survey was made along Red River between the State Road 3 highway bridge and the Red River Fish Hatchery. The primary purposes for this survey study were:

(1) Determination of the concentration of significant pond seepage water constituents in the ground water and spring water entering Red River.

(2) Determination of the amount of seepage water contained in the ground water and spring flows along specific reaches of Red River.

(3) Determination of the effect on Red River of the pond seepage discharge.

This study was conducted in conjunction with a ground water study, being prepared by South Pass Resources, Inc., to determine the characteristics of the ground water aquifer south of Dam No. 1 and the distribution and concentration of significant tailings pond water constituents in the ground water immediately down gradient of the pond areas.

Both studies were being conducted to determine the desirability and feasibility of further action by Molycorp to reduce the effect of seepage from the pond areas.

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SURVEY OF RED RIVER

The survey was conducted on April 12, 1993 between State Highway 3 and the fish hatchery. Six water samples were collected at selected locations along Red River. Four samples were collected from springs and drainages in the fields south of Dam No. 1 and five samples were collected from springs flowing into Red River along and at the head of the Red River Gorge. Both the warm and cold water fish hatchery supplies were sampled. A sample was collected from the 002 outfall. Samples were taken from the drainage below the 002 metering manhole and from a spring along the irrigation ditch east of that point. Conductivity and temperature measurements were recorded at all of the above and at an additional nine points in Red River and nine more spring or field drainage points. All samples were analyzed for sulfates, dissolved and suspended aluminum, molybdenum and ten other elements or parameters. The flow from many of the springs and field drainages were estimated at the time of the survey.

Subsequently the USGS recorded stream flow data was obtained for April 11, 12 and 13 at Red River near Questa (Ranger Station), Red River below the fish hatchery and Cabresto Creek near Questa. The fish hatchery superintendent was interviewed relative to the amount of cold and warm spring water that was being intercepted.

The following Table No. 1 is a summary of the more significant data obtained during the survey. Table 2 presents the complete data of the laboratory analysis of the water samples collected during the survey.

Drawing No. 1 shows the significant elements of the area and the location of the stream survey stations.

DATA BASE

Flow in Red River

USGS stream flow data indicates the following mean daily flows were present at the time of the stream survey.

Station	1993 April 11	April 12	April 13
Red River Near Questa (Ranger Station)	37	41	46
Cabresto Creek	11	11	12
Red River Below Fish Hatchery	62	65	70

The USGS data indicated measurement conditions were good during this time period. Good conditions under the USGS classification means that about 95% of the reported daily discharges are within 10% of the true value. Historic USGS stream flow data indicates that except for Cabresto Creek, there generally is not a significant amount of gain or loss in Red River between the Ranger Station and the highway bridge when irrigation water is not being diverted and there is not a significant amount of drainage from recent precipitation. The data indicates that there may have been a small amount of irrigation diversion on the date of the stream survey.

Table 3. is a tabulation of the USGS reported daily stream flows for March and April 1993. This table also shows the indicated gain or loss between the Ranger Station (plus Cabresto Creek) and the fish hatchery. Gains in

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TABLE 1
LOWER RED RIVER SURVEY 4-12-93
Summary of Survey Data

SAMPLE POINT	DESCRIPTION	RED RIVER COND	RED RIVER TEMP	RED RIVER SO 4	SPRINGS & DRAINAGE COND	SPRINGS & DRAINAGE TEMP	SPRINGS & DRAINAGE SO 4
	Below Hwy Bridge	345	8.3	119			
1.	Spring in field				398	10.5	92
2.	Field Drainage				456	8.3	--
2A.	Field Drainage				415	11.2	92
3.	Field Drainage				926	17.8	172
4.	RR above 3/4	369	9.3	--			
4A.	RR above 002	376	9.1	118			
5.	002				1984	9.7	840
6.	Field Drainage				450	9.3	
6A.	Seepage @ 002				1800	9.8	
6B.	Field Drainage				863	10.1	228
7.	RR above Big Spr.	418	9.8	141			
8.	Big Spring				1390	7.8	504
9.	Pipe @ Big Spr.				870	7.1	210
10.	RR below BS	412	10.3	138			
11.	RR above Pope	410	10.4	--			
11A.	RR above Pope	409	10.5	--			
11B.	RR @ Pope	410	10.5	--			
11C.	RR below Pope	410	10.4	--			
11D.	RR below Pope	410	10.4	--			
11E.	Spring				388	15.3	115
12.	RR above S12	410	10.5	128			
13.	Spring				407	15.8	--
13A.	Seep				410	14	--
13B.	Spring				436	14.5	--
13C.	RR	410	10.5				
13D.	South Side Spr.				450	16.9	126
14.	RR above S14	410	10.9				
14A.	Spring				238	16.4	20
15.	RR				284	16.3	
15A.	RR	404	11.2				
15B.	Spring				284	16.4	
15C.	RR	407	11	129			
16.	RR @ Div.Dam	407	11				
16A.							
17.	Hatchery Cold Spr.				430	8.3	80
18.	Hat-Warm Spr.				320	15.8	63
19.	Irrg. Ditch 002/003				1550	10.5	660
20.	Drain Below 002/003				1520	8.9	790

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TABLE 2.
WATER QUALITY SURVEY ALONG RED RIVER
BETWEEN STATE ROAD 522 AND FISH HATCERY
APRIL 12, 1993

SAMPLE SOURCE	PH	TOT ALK	F	TDS	SO4	TSS	MO	DIS. AL	CD	SUS. AL	FE	PB	CU	ZN	MN
#1 R/R Below Highway Bridge	7.23	38	0.84	255	119	31	<.03	<.5	<.005	7.8	0.594	<.1	0.036	0.250	0.92
#2 Spring N. Side R/R	6.76	90	0.55	247	92	20	<.03	<.5	<.005	0.5	0.543	<.1	0.007	0.021	0.02
#3 Field Drainage to R/R 500'E. of 002	7.44	99	0.60	246	92	7	0.20	<.5	<.005	<.5	0.405	<.1	<.005	0.047	0.05
#4 Field Drainage to R/R 450'E. of 002	8.22	94	0.46	648	172	6	<.03	<.5	<.005	<.5	0.115	<.1	0.008	0.012	0.05
#5 R/R 300'E. of 002	7.60	43	0.90	240	118	22	<.03	<.5	<.005	8.0	0.569	<.1	0.028	0.222	0.88
#6 Outfall 002	7.26	152	1.90	1764	840	2.0	1.80	<.5	<.005	<.5	0.102	<.1	<.005	0.010	1.40
#7 Field Drainage 75'W of 002	7.20	165	0.80	727	228	39	0.20	<.5	<.005	2.7	1.090	<.1	0.009	0.017	0.03
#8 R/R Above Questa Spring	7.14	50	0.88	268	141	21	<.03	<.5	<.005	6.2	0.573	<.1	0.029	0.207	0.88
#9 Near Questa Springs SE of Conc.Box	7.02	158	0.38	1094	504	88	<.03	<.5	<.005	8.5	2.940	<.1	0.016	0.047	0.07
#10 Near Questa Springs End of Old Pipe	7.50	177	0.60	576	210	7	<.03	<.5	<.005	<.5	<.05	<.1	0.005	0.010	0.01
#11 R/R 500'W. of Questa Springs	7.45	54	0.90	269	138	22	<.03	<.5	<.005	3.10	0.618	<.1	0.033	0.215	0.88

TABLE [illegible] (Cont.)
WATER QUALITY SURVEY ALONG RED RIVER
BETWEEN STATE ROAD 522 AND FISH HATCERY
APRIL 12, 1993

SAMPLE SOURCE	PH	TOT ALK	F	TDS	SO4	TSS	DIS. MO	DIS. AL	SUS. CD	SUS. AL	FE	PB	CU	ZN	MN
#12 Spring–N. Side R/R Sta. 47+20	6.94	82	0.80	271	115	47	<.03	<.5	<.005	1.70	2.36	<.1	0.011	0.046	0.13
#13 R/R Sta. 47+70 Above Hatchery	7.45	51	0.90	259	128	22	<.03	<.5	<.005	3.00	0.590	<.1	0.026	0.206	0.83
#14 Spring S. Side R/R Sta. 36+80	8.14	82	0.80	304	126	<1	<.03	<.5	<.005	<.5	<.05	<.1	<.005	0.005	0.01
#15 Spring N. Side R/R Sta. 36+40	7.26	80	1.10	145	20	<1	<.03	<.5	<.005	<.5	<.05	<.1	<.005	<.005	<.0
#16 R/R Sta.	7.80	49	0.90	247	129	24	<.03	<.5	<.005	3.10	0.527	<.1	0.024	0.191	0.781
#17 Hatchery Inlet Cold Water	7.14	43	0.64	176	80		<.03	<.5	<.005	<.5	0.138	<.1	<.005	<.005	<.0
#18 Hatchery Inlet Warm Water	7.87	77	1.10	284	63		<.03	<.5	<.005	<.5	0.181	<.1	<.005	0.010	<.0
#19 Seep Water in Irrigation Ditch Above 002 Line X @ Road	7.73	174	0.54	1304	660		<.03	<.5	<.005	<.5	0.160	<.1	<.005	0.013	0.05
#20 Molycorp Drain Below Culver Above Ditch	8.10	153	1.90	1702	790		1.70	<.5	<.005	4.00	2.4	<.1	0.016	0.010	2.00

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excess of 18 cfs during the first two weeks of March indicate run-off from spring snow melt along the survey reach. During the latter part of April the net gains were generally below 18 cfs because of irrigation diversions.

The USGS data also includes the river stage (gage height) at the stations on an hourly basis. The hourly data was used for determination of the specific probable stream flow at the average time of the stream survey.

Accretions to Red River

Previous studies have established that the accretion to Red River due to natural spring flow between the highway bridge and the mouth of Red River is fairly constant and amounts to approximately 32 cfs. Of this, the data indicates that 18 cfs originates above the fish hatchery. Hydro-geological analysis indicates that the majority of the spring flow is from the north side of Red River.

At the time of the stream survey, the irrigation ditches west of the highway were dry, there were no surface stream flows to the river along the survey reach and there did not appear to be any significant amount of drainage from precipitation. It is believed, therefore, that accretions to Red River at that time consisted essentially of the natural spring flow, the discharge from 002 and 003 and seepage from the tailings pond area which was not being intercepted by the 002 and 003 collection systems.

Fish Hatchery Diversions

The New Mexico Game and Fish Department has constructed facilities which intercept a large portion of the spring flow upstream of the hatchery. The intercepted spring water is transported to the hatchery by two pipelines. One pipeline extends to the large spring complex on the north side of the river at the upper end of the Red River Gorge. Water from this spring complex has a temperature of from 8°

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TABLE 3

USGS STREAM FLOW DATA - CFS

	MARCH		1993			APRIL		1993		
	RANGER	CABR.	RS &	BELOW		RANGER	CABR.	RS &	BELOW	
DAY	STATION	CREEK	CAB CK	F HAT	GAIN	STATION	CREEK	CAB CK	F HAT	GAIN
1	22	6.2	28.2	54	25.8	31	7.8	38.8	57	18.2
2	20	5.7	25.7	51	25.3	32	8.1	40.1	59	18.9
3	19	5.6	24.6	50	25.4	32	8.2	40.2	61	20.8
4	20	5.6	25.6	50	24.4	30	7.9	37.9	58	20.1
5	20	5.6	25.6	48	22.4	33	8.4	41.4	60	18.6
6	21	5.9	26.9	51	24.1	34	8.5	42.5	61	18.5
7	22	6.2	28.2	53	24.8	34	7.8	41.8	61	19.2
8	22	6.2	28.2	55	26.8	33	8.1	41.1	60	18.9
9	23	6.3	29.3	56	26.7	33	9.5	42.5	60	17.5
10	24	6.6	30.6	55	24.4	34	10	44	61	17
11	24	6.6	30.6	54	23.4	37	11	48	62	14
12	23	6.3	29.3	52	22.7	41	11	52	65	13
13	20	5.3	25.3	47	21.7	46	12	58	70	12
14	22	6.1	28.1	49	20.9	47	12	59	77	18
15	23	6.6	29.6	48	18.4	46	12	58	79	21
16	23	6.6	29.6	49	19.4	44	12	56	79	23
17	24	6.7	30.7	50	19.3	42	11	53	79	26
18	25	6.8	31.8	51	19.2	42	12	54	70	16
19	26	6.9	32.9	52	19.1	44	12	56	71	15
20	27	7	34	52	18	44	12	56	76	20
21	28	7.3	35.3	52	16.7	48	12	60	75	15
22	30	7.4	37.4	53	15.6	57	14	71	83	12
23	30	7.7	37.7	55	17.3	73	16	89	96	7
24	31	8	39	59	20	78	21	99	107	8
25	33	8.3	41.3	59	17.7	71	19	90	102	12
26	34	8.5	42.5	58	15.5	78	20	98	102	4
27	36	8.6	44.6	63	18.4	95	24	119	119	0
28	34	8.4	42.4	58	15.6	105	26	131	129	-2
29	34	8.3	42.3	59	16.7	115	29	144	135	-9
30	33	8.2	41.2	58	16.8	122	31	153	147	-6
31	32	7.8	39.8	57	17.2					

to 10°C and is referred to as the hatchery cold water supply. The other pipeline collects water from numerous springs west of the upper end of the gorge. Water from these springs has a nominal temperature of 16°C and is referred to as the warm water supply.

It is believed that the cold water springs are fed by ground water from the alluvial aquifer east of the Guadalupe Mountain volcanic formations which flows primarily along the frontal lobe of the volcanics and/or along the easterly most volcanic formation fault zone.

The warm water springs emanate from the volcanic formations along the Red River Gorge. The higher temperature of this spring water is attributed to heat gains from the volcanic formations.

Flow meters have been installed on both the warm and cold water supplies to the hatchery. At the time of the stream survey, however, neither meter was operating properly. The hatchery superintendent advised that the warm water supply normally ranged from 4600 to 4700 gpm (10.2 to 10.5 cfs) and the cold water supply varied from 900 to 1500 gpm (2.0 to 3.3 cfs). The flow at the time of the stream survey was estimated at 10 cfs for the warm water supply and 2.7 cfs for the cold water supply.

Ambient Ground Water Quality

Table 4 lists the water analysis for a number of springs and wells up gradient or out of the tailings pond seepage flow path. Winograd in Technical Report No. 12, indicated that the quality of water in the volcanics and in the alluvium formations was nearly the same.

TABLE 4
WATER QUALITY OF SPRINGS AND WELLS
IN THE VICINITY OF GUADALUPE MOUNTAINS

WATER SOURCE	LOCATION Sec	Twp	Rng	AGENCY	DATE	SPEC. COND. umhos	TDS mg/l	pH units	SO4 mg/l	CALCIUM mg/l	MAG-NESIUM mg/l	CHLORIDE mg/l	FLOURIDE mg/l	IRON ug/l	MANGANESE ug/l	MOLY-DENUM ug/l	ZINC ug/l
Big Arsenic Springs	8	28	12	USGS	10-07-80	228	161	8.2	22.0	18.0	4.8	6.9	---	<10	2	<10	---
Big Arsenic Springs	8	28	12	USGS	08-20-82	220	159	7.9	22.0	20.0	5.1	6.8	1.2	4	3	---	13
Big Arsenic Springs	8	28	12	EID	01-13-83	226	162	7.5	23.7	18.0	5.7	8.0	---	---	<10	---	<50
Big Arsenic Springs	8	28	12	EID	07-23-84	---	160	---	24.8	16.3	5.6	6.0	---	<50	<10	<50	<50
Big Arsenic-North Springs	8	28	12	EID	01-13-83	229	163	7.5	23.7	19.4	5.4	8.0	---	---	---	<10	<50
Big Arsenic-Meadow Springs	8	28	12	EID	01-13-83	192	163	7.5	23.7	19.4	5.4	8.0	---	---	<10	---	<50
Big Arsenic-Meadow Springs	8	28	12	EID	11-08-84	---	154	---	29.6	22.4	7.8	6.3	1.2	<100	<50	<10	<50
Big Arsenic-Meadow Springs	8	28	12	EID	05-30-85	---	165	---	24.5	24.0	8.3	8.6	---	110?	<50	<10	<10
Big Arsenic-High Springs	8	28	12	EID	11-08-84	---	---	---	---	21.6	3.9	---	1.08	480?	<50	<10	---
Big Arsenic-High Springs	8	28	12	EID	05-30-85	247	170	---	24.5	11.2	20.0	6.8	---	<50	<50	<10	---
Chiflo Springs				EID	05-30-85	218	---	---	26.6	22.5	17.6	7.0	---	---	---	---	---
BLM Visito Center Well	9	28	12	USGS	08-20-82	220	156	7.9	20.0	19.0	5.0	7.0	1.2	7	3	---	48
BLM Chiflo Wells	9	28	12	USGS	08-20-82	220	158	8.0	23.0	19.0	5.2	6.9	1.3	3	10	---	97
Mottle Spring-Red River	9	28	12	USGS	08-19-82	220	---	7.5	---	---	---	---	---	3	8	6	<3
Warm Spring-Red River	9	28	12	EID	02-21-84	---	164	---	21.7	24.0	5.9	9.7	---	---	<10	---	<100
MC Guadalupe Well 4 (Average of 7 samples)	22	29	12	MC	12-87	---	167	7.5	50.1	20.5	4.9	8.7	1.1	5	2	<2	150
MC Guadalupe Well 5 (Average of 5 samples)	33	29	12	MC	11-85	---	167	---	18.8	20.4	5.4	7.6	1.1	3	14	<2	40
ALLUVIUM WELLS																	
Top of World Farm	35	1	74		1955	217	136	7.7	8.8	24	5.7	5.0	0.8	---	---	---	---
Anderson Well	16	12	30		1954	194	---	7.2	---	---	---	4.5	---	---	---	---	---
Carter Farm	24	12	30		1954	190	---	---	43	36	2	18	---	---	---	---	---
WATERS APPEARING TO BE ABOVE NATURAL AMBIENT																	
Fish Hatch. Cold Springs	1	28	12	EID	10-18-84	---	306	---	70.6	50.4	7.9	5.7	0.73	<50	<50	10	<50
Spr. Across from STP	1	28	12	EID	10-15-84	---	320	7.2	81.3	50.0	8.2	6.0	0.67	<100	<50	15	---
Fish Hatch Spr. Coll. Box	2	28	12	EID	10-16-84	---	460	---	152.	84.6	14.0	7.0	0.73	<100	<50	22	<50
Fish Hatch.Warm Springs	3	28	12	EID	10-16-84	---	158	---	43.2	19.0	6.7	10.3	---	<100	<50	14	<50

Where analysis was made all samples had concentrations
of cadmium, copper and lead near or below the detection limit.

Tailings Seepage Water Quality

For the analysis and this report it was assumed that the concentrations reported in Table 2 for sampling point No. 6 (002 outfall) reflected the quality of the tailings pond seepage flow.

ANALYSIS

A large part of the analysis was based on the following selected values:

Table 5

Selected Analytical Values

Element	Flow CFS	Sulfate mg/l
Red River @ Hwy.Bridge	46.0	119
Total Natural Spring Flow	18.0	20
Hatchery Warm Water Supply	10.0	63
Hatchery Cold Water Supply	2.7	80
Tailings Pond Seepage	---	840
Red River Below Fish Hatchery	66.29	---

The selected value for the flow in Red River below the fish hatchery was based on the USGS reported hourly stage reading at the estimated average time when the flow during the survey was passing by the station. The flow at the highway bridge was derived by subtracting the assumed and calculated accretions above the hatchery from the flow in Red river at the station below the hatchery. The sum of the Red River flow at the Ranger Station plus Cabresto Creek was approximately 49 cfs at that time indicating a nominal difference in the flow measurements and/or that there may have been a small amount of irrigation diversion from the reach above the highway bridge.

The ambient concentration of sulfate for the natural ground water flow was conservatively selected at 20 mg/l which is slightly below the average of the concentrations for the springs and wells listed in Table 5. If a higher value had been used, the calculated amount of tailings pond seepage flow would have been slightly less.

Other values for the analysis were taken from the data base set forth herein and/or laboratory data for the survey water samples.

Additional mathematical analyses, not included herein, were made using changes in water temperature, conductivity and concentrations of other constituents. These analyses in general supported the results of the analysis based on sulfates. The results, however, appeared to be less precise.

(a.) Calculations of Total Seepage Flow.

Inflow	CFS	Mg/l SO_4
RR @ Hwy	46.0	@ 119
Natural Spring Flow	18.0	@ 20
Tailing Seepage	S	@ 840

Outflow

Red River above Hatchery	+ 46.0		
(Nat.Spring Flow	+ 18.0		
(F.H. Warm Water)	- 10.0		
(F.H. Cold Water)	- 2.7		
(Seepage Flow)	+ S		
	=	(51.3+S)	@ 129
F.H. Warm Water		10	@ 63
F.H. Cold Water		2.7	@ 80

160016

Multiplication CFS X Conc:

$$5474 + 360 + 840S = 6618 + 129S + 630 + 216$$

by Subtraction:

$$711S = 1630$$

by Division:

$$S = \text{Total tailings seepage flow} = 2.29 \text{ cfs.}$$

(b.) <u>Warm Water Spring Flow</u>

The stream survey found several springs along the upper part of the Red River Gorge which had sulfate concentrations somewhat higher than the ambient natural ground water. It was presumed that these springs were in the flow path of and included tailings pond seepage. An SO_4 concentration of 120 mg/l was selected as being representative of these springs.

No springs with elevated SO_4 concentrations were detected downstream of sampling point 14 indicating that this was the westerly limit of the tailings pond seepage flow path. An SO_4 concentration of 20 mg/l was assumed for spring flow below Station 14. This value was also used for spring flow to Red River from the south. (Some of the springs along the south side of Red River had elevated SO_4 concentrations indicating that ground water from the north was flowing beneath Red River with discharge at fissures along the south shoreline).

Based on SO_4 concentrations of 20 mg/l for the natural ground water and 840 mg/l for seepage water, the spring water which had a concentration of 120 mg/l consisted of 87.8% of natural ground water and 12.2% seepage water.

The warm water supply to the fish hatchery is composed of both spring water from the flow path down gradient of the tailings ponds (120 mg/l) and spring water west of the flow path and from the south (20 mg/l). The laboratory analysis of the combined hatchery warm water supply indicated a SO_4 concentration of 63 mg/l. Mathematical calculations therefore indicate that 43% of the warm water supply consisted of spring flow within the pond seepage flow path (120 mg/l) and 57% from spring flow outside the seepage path (20 mg/l).

The estimated warm water hatchery supply was 10 cfs. Calculations indicated that this consisted of 5.70 cfs of spring water from outside the seepage path (20 mg/l) and 2.27 cfs of spring flow within the seepage path (120 mg/l).

The 2.27 cfs of spring flow within the seepage path was composed of:

1.99 cfs of natural ground water flow

0.28 cfs pond seepage flow.

(c.) Hatchery Cold Water Supply

The hatchery cold water supply is obtained from the spring complex on the north side of Red River near the upper end of the Red River Gorge. The cold water supply was estimated to be 2.7 cfs at a SO_4 concentration of 80 mg/l. Based on the selected values of 20 mg/l for natural ground water flow and 840 mg/l for pond seepage water, the cold water supply consists of 2.50 cfs of natural ground water flow and 0.20 cfs of seepage flow.

(d.) Balance of Accretions to Red River

Subtraction of the determined discharges (F.H. warm and cold water supplies and discharge from 002) from the total calculated accretion (18.0 cfs spring flow plus 2.29 cfs seepage flow) leaves a balance of 6.99 cfs at an average SO_4 concentration of 133.8 mg/l to be accounted for. The assumed sources of the unaccounted for accretion were:

(1.) Warm spring flow direct to Red River from west of the pond seepage path and from the south side.

(2.) Warm spring flow within the pond seepage path direct to Red River.

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(3.) Cold spring flow direct to Red River from the spring complex near the upper end of the gorge.

(4.) Field drainage and alluvial ground water flow upstream of the Red River Gorge.

It was found that there were too many variables for mathematical determination of the distribution of the remaining amount of accretion to the various sources. Calculations based on assumed allocations, however, revealed that there was a fairly narrow range of possible flows from each source which would total 6.99 cfs at an average concentration of 133.8 mg/l SO_4.

Assumptions used to arrive at the most probable allocation included:

(1.) The warm water spring flow direct to Red River probably consisted of spring water flow outside the pond seepage path approximately in the same ratio to spring flow within the seepage path as contained in the warm water supply line (i.e. 57% - 43%) and that the SO_4 concentrations were probably nearly the same.

(2.) The cold water spring flow direct to Red River probably has the same SO_4 concentration as the cold water supply to the hatchery. (Water samples from stations 9 and 10 are believed to be from field drainage and shallow alluvial ground water flow rather than from the main cold water spring flow.)

(3.) The significant increases in river water temperature indicates that a large part of the unaccounted for accretion is from warm water spring flow.

(4.) There is a significant amount of field drainage and shallow ground water flow from the alluvial formation upstream from the large spring complex at the upper end of the Red River Gorge. Such is evidenced by the fairly significant indicated increase in the

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indicated SO_4 concentration in the vicinity of sampling point No. 8. The average SO_4 concentration of the field sampling points (Stations 3, 4, 7, 9 and 10) is 240 mg/l. This value was assumed to be representative of the field drainage and flow from the shallow alluvium.

(5.) Accretions with a SO_4 concentration in excess of 134 mg/l must be present to offset the accretions from the cold and warm water springs which have concentrations of less than 134 mg/l.

Based on the above assumptions and other valid considerations, the most probable distribution of the unaccounted for accretions appeared to be as follows:

(a.) Warm water spring flow from the north side of Red River west of the pond seepage path plus spring flow from the south side of Red River. ---2.81 cfs @ 20 mg/l SO_4.

(b.) Warm water spring flow direct to Red River within the seepage path of the tailings pond area --- 1.65 cfs @ 120 mg/l SO_4. (This flow would consist of about 1.45 cfs of natural ground water and 0.20 cfs of seepage water.)

(c.) Cold water spring flow direct to Red River -- 0.40 cfs @ 80 mg/l SO_4. (Composed of .37 cfs of natural ground water and 0.03 cfs seepage flow.)

(d.) Field drainage and shallow alluvial flow east of the cold water spring complex -- 2.67 cfs @ 240 mg/l SO_4. (Composed of 2.02 cfs natural ground water flow and 0.74 cfs of seepage flow).

A schematic diagram showing the above distribution of accretion flow and all of the other measured and derived spring and river flows and SO_4 concentrations is included at the end of this report.

SUMMARY AND CONCLUSIONS

At the time of the stream survey (April 12, 1993) the quality of the water in Red River (relative to constituents associated with Molycorp's operations) was better below the fish hatchery than at the State Highway bridge. The sulfate concentration was nearly the same. The concentrations of aluminum, iron, copper, zinc and manganese were all lower at the downstream point. Concentrations of molybdenum, cadmium and lead at both the upstream and downstream ends of this reach, were all below the detection limits for the laboratory methods used. Except for manganese, all constituents analyzed were below drinking water and stream water quality standards. The high manganese concentration are due to concentrations in the river upstream of the tailings pond area.

The quality of the natural ground water in the area is excellent. The average sulfate concentration is low at only slightly more than 20 mg/l.

Except for TDS and SO_4; the seepage flow from the tailings ponds compares favorably with Red River water quality.

The majority of the natural spring flow along the survey reach is intercepted by the fish hatchery water supply system. Analysis of the hatchery water supply indicates a moderate increase in sulfate; however, the concentration (63 - 80 mg/l) is still far below drinking and ground water standards. The maximum SO_4 concentration found for any individual spring was 126 mg/l. (Sampling

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points 9 and 10 are believed to be field drainage and shallow alluvium aquifer flow rather than spring flow.)

High concentrations of sulfate (660 - 690 mg/l) were found down gradient of the junction manhole from 002 and 003 which is located in the natural drainage channel below Dam No. 1. and about 1/4 mile north of Red River. Other data indicates elevated SO_4 concentrations in some monitor and private wells in and down gradient of this area. The highest SO_4 concentration detected near the river was 504 mg/l at Station No. 9. We believe that the field drainage below Dam No. 1 and 003 is concentrated at this location. Molycorp is presently investigating the feasibility of constructing additional seepage barriers and/or other facilities to substantially reduce the seepage flow down gradient of the tailings ponds in this area.

Data from the stream survey indicates that at that time, the total tailings pond seepage flow entering Red River (including the fish hatchery supply) was about 2.29 cfs (including discharge from 002 and 003). Of this about 0.6 cfs was flowing from 002 and 003. 0.7 cfs were in the field drainage and shallow alluvium aquifer flow east of the volcanic formations. These seepage flows are presumably from the tailings ponds in Section 36 and the easterly part of the tailings ponds in Section 35. An additional seepage flow of about one cfs was indicated to be contained in the cold spring flow at upper end of the gorge and in the warm springs along the gorge. It is believed that this seepage flow is from the west side of the pond area in Section 35 and from the pond area above Dam No. 5. Survey data indicates that the seepage path from these areas extends downstream to within about 1/2 mile east of the fish hatchery.